Wave-power device

The invention relates to a device in accordance with the introductory part of claim 1, for the converting of kinetic energy in water waves into electrical energy, here called a wave-power device.

Background

From Japanese patent specification 55160967 (Yasuhiro 1980) it is known to arrange a plurality of floating bodies in rows on a raft, with bars which extend upwardly from each floating body to a linear generator. Such a structure can be towed carefully, and can be operated without another connection to the bottom other than mooring chains or hawsers. However the towering generator parts create potential problems during storms. Therefore, this design did not receive attention for any practical use.

From German patent publication 43 38 103 (Klemm 1995) a wave-power device in accordance with the introductory part of claim 1 is known, where there is a row of stator tubes with coils, which are fastened in a frame, are inserted flotation gears with permanent magnets, which form a rotor of a linear generator. The capacity of such a generator will be too small for feeding electricity into the public mains and producing profit as an energy supplier.

From US-patent specification 3.546.473 (Rich 1969) it is known to make an energy converter with a floating body which forms a moving part of a linear generator, while the other parts are anchored to the seabed. This solution results in problems with the tides, and is calculated for a very low profit.

From US-patent specification 4.742.241 (Melvin 1988) it is known to couple together several energy converters in an electro-hydraulic system, as several floating bodies each drives its reciprocating pump which is coupled in parallel for the operation of one or several hydraulic motors. This construction will be expensive on account of the many pumps which have to be produced with high precision, and which are exposed to operational disturbances in a demanding environment.

From US-patent specification 4.622.473 (Curry 1986) a similar reciprocating piston-type system as mentioned above is known, which is coupled to a platform

structure. Also, in this case, the costs will be high, and the many mechanical elements will be exposed to wear and climatic influence.

Object

The main object of the invention, therefore, is to create a wave-power device which has lower investment costs in relation to the electricity generated than known constructions, and which can be operated with little maintenance. The aim is to be able to place many such units in sea areas with waves.

It is a particular object to create a wave-power device which can be built up with simple parts, and which makes it easy to couple together several floating units to a power station.

Invention

The invention is quoted in claim 1, as claims 2-12 quote particular advantageous details. With such a device it becomes possible to build up a wave-power device, that means a construction for converting wave energy to electrical energy, which is assembled from reasonable parts, where the costs of capital and maintenance are held low, so that electricity can be supplied at a competitive rate. A wave-power device, according to the invention can be made resistant to bad weather, and other climatic strains.

Several details of the invention can be learnt from the following description of an example.

Example

Below, the invention is described more closely with reference to an example, where

Figure 1 schematically shows a side view of a wave-power device designed according to the invention,

Figure 2 shows a top view of the wave-power device according to Figure 1,

Figure 3 shows a sectional side view of a floating body which is adjusted for use with the wave-power device according to Figures 1 and 2, while

Figure 4 shows a coupling pattern for the wave-power device according to Figures1-3.

In Figures 1 and 2, a wave-power device 11 with floating bodies 12 arranged in a lattice-like structure is shown. Shown is a device with three rows, with five floating bodies in each row, but it is hinted that there can be arranged some more floating bodies in each row. This number is chosen as an illustration of a possible solution, as the dimensioning can vary within wide limits, particularly in view of the number in the longitudinal direction.

The floating bodies 12 are shown to be spherical, but they can have other geometrical shapes, for example discus-form or an upright cylinder-form. Each floating body 12 has a vertically directed, cylindrical opening 13, which is approximately of the same dimension as a vertical supporting bar 14, so that the floating body 12 can move up and down in a vertical direction on its supporting bar 14, with relatively little clearance. The opening 13 can be encircled at its underside with a suitable scraper which enables the supporting bar 14 to be kept free of fouling.

The upper and lower ends of the supporting bars 14 are connected with a network of connection bars 15, 16 and 17, 18 on top and at the underside, respectively, where these run lengthwise and crosswise, respectively. The connection bars 15-18 can be made of semi flexible compound material, for example fibre glass reinforced plastics, with appropriate juncture elements (not shown).

At each side of the wave-power device 11, outside of the floating bodies 12, is arranged a crosswise directed buoyancy tank or pontoon 19, 20 which can be completely or partially be filled with water. The buoyancy tanks 19, 20 are fastened to lengthwise directed lower connection bars 17, with the aid of a crosswise directed strut 33, which, at its ends, is fastened to the axis 34 of the buoyancy tanks 19, 20. In this way it is possible to turn the buoyancy tanks 19, 20 for gaining access for the removal of fouling from the underside.

When the wave-power device is activated after tow-out from a production site, the buoyancy tanks 19, 20 are filled with so much water that they will be lowered down to a depth, where the buoyancy tanks and the bearing structure stays mainly insensitive to wave movements. In this position, the device can be secured with mooring chains 21 at the corners of the network of the lower connection bars 17, 18. The mooring chains 21 can be anchored to a concrete block placed on the seabed. With an alternative embodiment, four mooring chains can be assembled to a juncture under the wave-power device, as this juncture is anchored to the bottom. In this way the wave-

power device according to the invention, can be moored to a single mooring point during bad weather.

Figure 3 shows an example of the structure of a floating body 12, and the assigned supporting bar 14 with an embodiment in which is integrated a linear generator 22. Each floating body can have a volume from 40-3000 dm^3, and can be made with a sperical shell 23, for instance of fibre glass reinforced plastics, which is filled with foam material 24. The opening 13 for the supporting bar 14 is formed of a tubular structure of annular permanent magnets 25, placed axially to each other, and separated by nonmagnetic distance pieces 26, for example by embedding with plastic or sticking. The tubular structure of the permanent magnets 25, which can be of circular or rectangular cross-section at its opening, forms the rotor or moving part of the linear generator 22.

The stator of the linear generator is built up on the supporting bar 14. In a part of the area covered by the floating body 12, it includes a row of coils 27 which are placed alternately with a row of iron elements 28. As a central support in the supporting bar 14, a tube or compact bar 29 of suitable material may be used. By using a tube it can serve as a channel for the carrying of a power cable 30 down to the lower connection bars 17, 18, and from there to a converter. In the supporting bar 14, there can also be placed a capacitor for stabilizing the generated current, and possibly a rectifier.

Figure 4 shows a diagram of the electric circuit of a wave-power device according to the invention. For each floating body 12, there is shown a coil 27, a permanent magnet 25, and a rectifier 31. All partial generators 22 are connected in parallel to a DC/AC-converter 32, which can deliver regulated alternating current to an outer network.

Further, the buoyancy tanks 19, 20 can be filled for lowering of the wave-power device down in the sea, so that the floating bodies 12 go down to a level and thus remove any risk of damage during bad weather.

With an alternative embodiment, there is integrated in each floating body, an electric generator with a rotating armature with permanent magnets, where the transmission of forces takes place over a pitch rack which is engaged by a gear for driving the rotating armature, which in this way converts wave movements to electrical energy. The energy transfer from the generators in the floating bodies can be done with flexible power cables.

With a further alternative embodiment, each floating body can be fastened to a vertical bar which is guided in guides which are arranged at the cross-over of the connection bars 15-18. This vertical bar can be provided with an upper or a lower partial pitch rack which can drive a generator with a rotating armature.